Scientific Method: There's a Method to the Madness

Name:______________________

It's a mad, mad world, and sometimes, it's hard to make sense of it all. Questions like "where did we come from?", "why do birds fly?" and "why is the sky blue?" make our brains melt and promptly cause our foreheads to hit our lab desks at a high rate of speed. Luckily, there's a solution! Scientists have developed this nifty thing called the scientific method to help us find answers to questions about the world around us!

In the scientific method you must first ask a question or identify a problem you would like to solve, such as, "is this spicy chicken sandwich still safe to eat if it dropped on the floor and I picked it up five seconds later?" You must use your skills of observation (your five senses) and inference (making a judgement based on experience or evidence) to predict an answer to your question. You infer that because the sandwich was on the floor beyond the "three second rule", it may be covered in bacteria and not safe to eat.

One important thing about observations is that they should be objective, or free of personal opinion, bias or emotion. A person whose observations are affected by public opinion, personal taste or experience, is considered to be making a subjective observation. A perfect example of this would be to look at product reviews of a new smartphone on Amazon. Individually, each review is subjective – based on the person's personal experience with the phone. However, if you are a potential *buyer* of that phone, you should take an *objective* look at ALL of the reviews to get a general feel for the phone, looking at the technical specifications, and any possible drawbacks and benefits before purchasing it. Observations can also be qualitative or quantitative, depending on what you're observing. The "quality" of things like color, texture, shape or other characteristics or descriptions like "muddy" or "frosty", are qualitative observations. Measurements, like length, temperature, or the "quantity" of something, are considered quantitative observations.

Once you have made your observations and know what you want to investigate, you should form a hypothesis. When you hypothesize, you make an "if..., then..." statement, or a prediction of the possible outcome to your question or problem, similar to making a forecast of the future: if bacteria attach to a substance within five seconds, then my sandwich will be safe to eat if I pick it up off of the floor prior to three seconds.

After you predict a solution to your problem, you create an experiment in order to test your hypothesis. You should develop a reliable experiment that is composed of steps that are so detailed and easy to follow that anyone can replicate your test and carry it out just like you did. So, your experiment might go like this: "I will make 13 spicy chicken sandwiches. One of them will serve as my control and I will test the amount of bacteria on the outside of the sandwich by swabbing and then growing the bacteria in a petri dish for three days. Four of them I will drop on the floor of my kitchen near the sink and pick up after three seconds and swab each one for bacteria. Four sandwiches I will drop and leave on the floor for five seconds and swab for bacteria. My remaining four sandwiches I will drop and leave on the floor for 10 seconds and then swab for bacteria."

Also, it is important that you only change ONE thing during your experiment. This is called the independent variable. It is what you are testing - the amount of time the sandwich spends on the floor. What happens as result of that change is called the dependent variable. It is what you are measuring and "depends" on the independent variable - the amount of time the sandwich spends on the floor determines the amount of bacteria it collects. All other things that remain the same in your investigation are called controls – the type and amount of bread, lettuce, meat, and condiments used, the location the sandwich was dropped, whether or not you washed your hands prior to dropping each one. If any of your controls change, it will be difficult to determine what caused the bacteria to grow: was it the amount of time on the floor, or was it that I dropped it in the bathroom versus the kitchen that cause an increase in the amount of bacteria?

Now it's time to perform the experiment. Follow your steps exactly and record all of your numerical data and observations in a table so it is organized. "Time to drop my sandwiches and swab for bacteria! Wow, the petri dishes for the sandwiches that were left on the floor for three seconds had an average of three bacterial colonies, each less than 1.5cm in diameter. The five second sandwiches had an average of four colonies, each less than 2cm in diameter. Lastly, the 10 second sandwiches developed six colonies averaging 2cm each. I need to put this in my data table!" When your investigation is complete, you need to analyze your data. "The sandwiches that spent more time on the floor had more colonies than those that spent less time on the floor. Now what?" Draw a conclusion - what does it tell you about your hypothesis? "The longer a sandwich spends on the floor, the more bacteria it accumulates AND the three second rule doesn't exist!!"

So, what happens when your results don't add up? If necessary, you'll need to revisit your hypothesis and possibly modify your experiment. Go back and change your experiment, or if necessary, create an entirely new experiment. No matter what your investigation results yield, you will always need to communicate your results. The public and other scientists need to know what you found, good or bad, so that they may build upon your knowledge and support or reject your hypothesis on their own. For the time being though, you may not want to chow down on that bacteria-ridden chicken sandwich.

Scientific Method: There's a Method to the Madness

Name:______________________________

Use the reading to answer the questions below:

1. Fill in the graphic organizer with the steps of the scientific method and describe each in the space provided

↓
↓
↓
↓
↓
↓

2. At any point in time if your results are a bit "off" you can ____________________________
3. When you make an observation, what are you using? ____________________________
4. Fill in the graphic organizer below:

Type	QUALITATIVE	QUANTITATIVE
Definition		
Give TWO Examples		

Scientific Method: There's a Method to the Madness

Name: ____________________

(continued...)

5. Define the following and explain how they are used in an experiment:
   OBSERVATION: ____________________
   INFERENCE: ____________________
   PREDICTION: ____________________

6. Compare and provide an example of each:

   OBJECTIVE

   SUBJECTIVE

7. Explain why it is important to make OBJECTIVE observations when doing science. ____________________

8. Describe the following components of an experiment:
   a. Independent variable: ____________________
   b. Dependent variable: ____________________
   c. Controls: ____________________

9. Explain why it is important to communicate your results even if your experiment did not go as planned.

Scientific Method: There's a Method to the Madness

Name:________________________

(continued...)

Use the reading to answer the questions below:

1. List in order the steps of the scientific method.
   1. ____
   2. ____
   3. ____
   4. ____
   5. ____
   6. ____
   7. ____

2. At any point in time if your results are a bit "off" you can ____________________
3. When you make an observation, what are you using? ____________________
4. Identify each as a **QUALITATIVE or QUANTITATIVE** observation.
   a. ________________ That knife is sharp and has a serrated edge.
   b. ________________ Her newborn baby weighs 6 pounds and 12 ounces and measured 20 inches long.
   c. ________________ He travelled thirty-four miles to the conference yesterday.
   d. ________________ The weather is overcast today.
   e. ________________ Apple juice has the same amount of sugar as five Swiss Cake Rolls.
5. Identify the following as **SUBJECTIVE or OBJECTIVE** statements:
   a. ________________ I heard the movie was really scary and that it would make me have bad dreams.
   b. ________________ I heard the director used top quality cameras and cutting-edge special effects.
6. What does it mean to "infer"? ____________________
7. What is a hypothesis? ____________________
8. Define the following components of an experiment:
   a. Independent variable: ____________________
   b. Dependent variable: ____________________
   c. Controls: ____________________

7. Why do you think it is important to communicate your results even if your experiment did not go as planned?

____